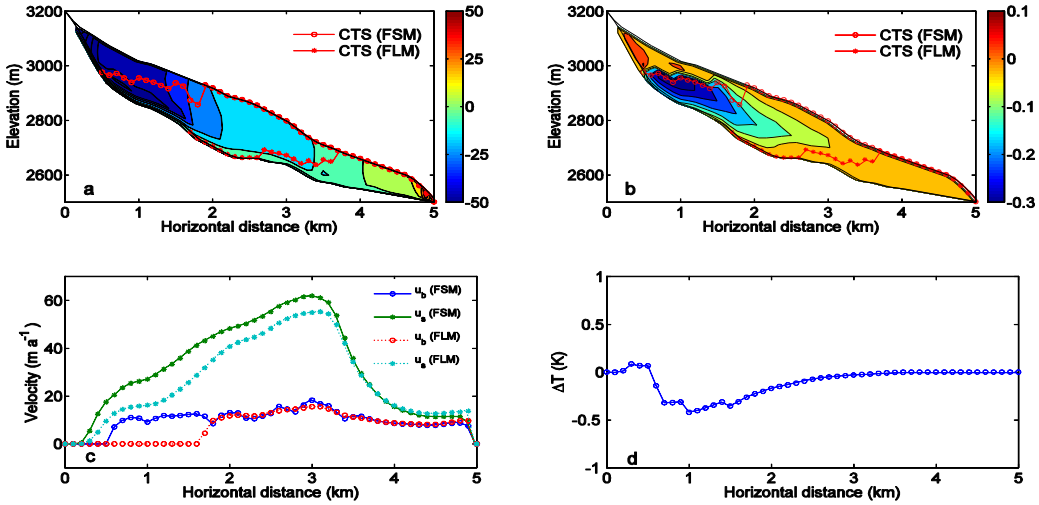
A Comparison of 2D, First-Order & 3D, Full-Stokes Modeling of Land Terminating Glaciers

Objective

A systematic study on the applicability of a two-dimensional (2D), first-order Stokes approximation flowline model relative to the highest fidelity and currently accepted “gold standard”, a three-dimensional (3D), “full”-Stokes ice-flow model

Methods

- Apply both models to identical simulations of a realistic, land terminating glacier geometry commonly applied to community benchmark experiments
- Treat 3D, full-Stokes model results as “truth”
- Examine output from experiments with varying degrees of complexity and coupling including:
    - steady-state temperature evolution
    - transient temperature evolution
    - themomechanically uncoupled
    - themomechanically coupled



Equilibrium velocity (left) and temperature (right) differences between the 3D Stokes (FSM) and 2D flowline (FLM) models. Differences in upper vs. lower panels are given in percent and absolute value, respectively.

Results

- A 2D, first-order Stokes approximation flowline model is not suitably accurate for simulations of:
    - steep glaciers with complex bed topography
    - sliding glaciers with temperate basal ice
    - themomechanically coupled evolution over long time periods (order 10^3 years)
- Overall, this model should be applied and interpreted with caution when modeling glacier changes under a warming climate and/or over long time periods

Zhang, T., L. Ju, W. Leng, S. Price, and M. Gunzburger, 2015: Thermomechanically coupled modelling for land-terminating glaciers: a comparison of two-dimensional, first-order and three-dimensional, full-Stokes approaches. *J Glaciol*, **61**, 702–712, doi:10.3189/2015JoG14J220.